

# Neutron irradiation of SiPMs at ATOMKI, Debrecen

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# Literature

Year	Fluence (1MeV eq. n/cm <sup>2</sup> )	SiPM	Cell size (μm)	V <sub>bd</sub> shift (mV)
<u>2009</u>	2E10	HPK	50	
		CPTA/Photoniq ue	42	
		MEPhI/Pulsar	31	<50
		FBK	50	
		Zecotek	45	
<u>2015</u>	2E12	HPK	15	175
		KETEK		<50
		FBK		
<u>2016</u>	6E12	HPK	10	200
	2.2E14			~4000
		FBK	12	500

# Irradiation facility

- Neutron irradiation: Be (p, n)
- Continuous energy spectrum (up to 17MeV)
- See *curve a* in the figure

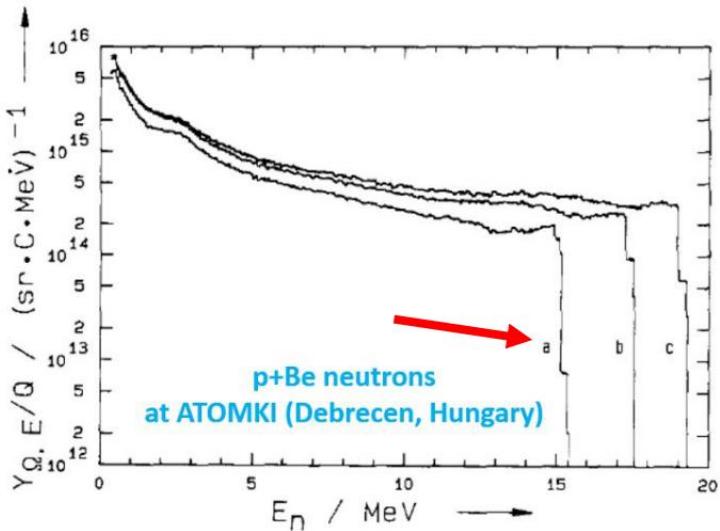


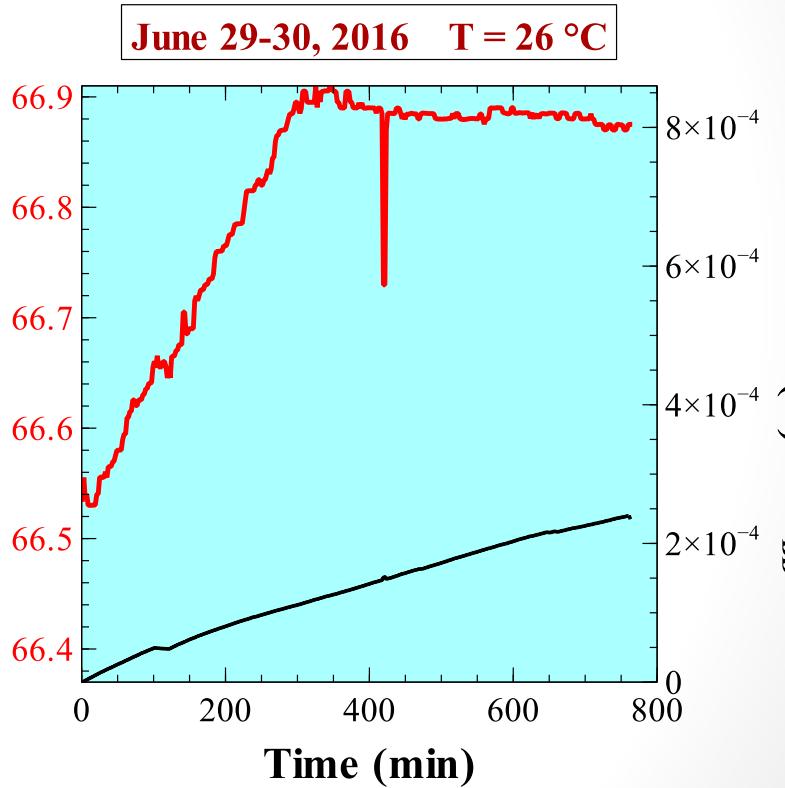
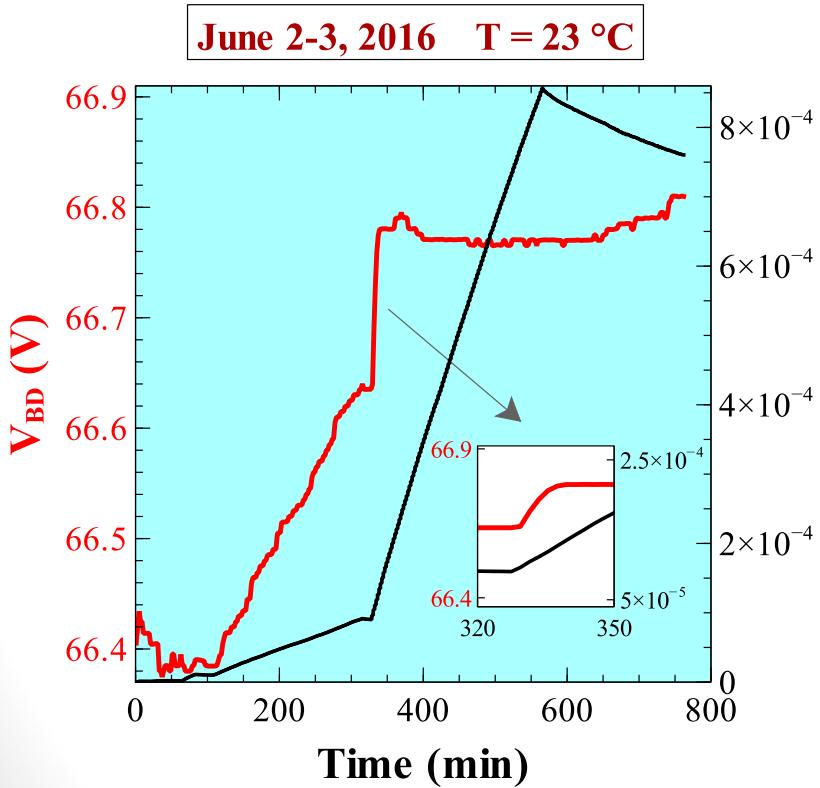
Fig. 8. Spectral neutron yield per unit beam charge on the Be target,  $Y_{\Omega,E}(0^\circ)/Q$ , for various proton energies  $E_p$ . Curve a corresponds to  $E_p = 17.24$  MeV, curve b to  $E_p = 19.08$  MeV and curve c to  $E_p = 20.97$  MeV.

Taken from H. J. Brede et al., *Nucl. Instr. Meth. A274*(1989)332-344

# Measurement

- Device: Hamamatsu MPPC S12572-015P
- 780 minute-long continuous tracking
- Every 2 minutes an I-V curve was taken
- I-V curve: 63-71 V in 50 mV steps
- Two params were extracted from the I-V curves:
  - $I_{dark}$  at  $V_{BD} + 3$  V
  - $V_{BD}$  by 3<sup>rd</sup> derivative method, interpolated between 50 mV steps
- Two irradiation sessions
  - June 2-3 2016 - in 4 steps:  $1.4 \times 10^9$ ,  $10^{10}$ ,  $10^{11}$ ,  $10^{12}$  n/cm<sup>2</sup>
  - June 29-30 2016 – in 1 step:  $\sim 3.7 \times 10^{11}$  n/cm<sup>2</sup>

# Two neutron irradiation runs



# Conclusions

- $V_{BD}$  increased gradually by  $\sim 400$  mV until a fluence of  $\sim 1.5 \times 10^{11}$  n/cm<sup>2</sup>
- Above this fluence  $V_{BD}$  stopped increasing
- The phenomenon did not depend on the dose rate

# Equivalent circuit of gamma background

(since this is an electronics meeting)

- Neutron irradiation activates a gamma background
- SiPM current is proportional to the gamma background
- So  $I_{\text{dark}}$  happens to reveal the total neutron fluence
- See the resemblance of  $V_{\text{out}}$  below to  $I_{\text{dark}}$  in left plot of Slide 5

